AIRS Retrieval of Cloud Radiative Properties over Antarctica

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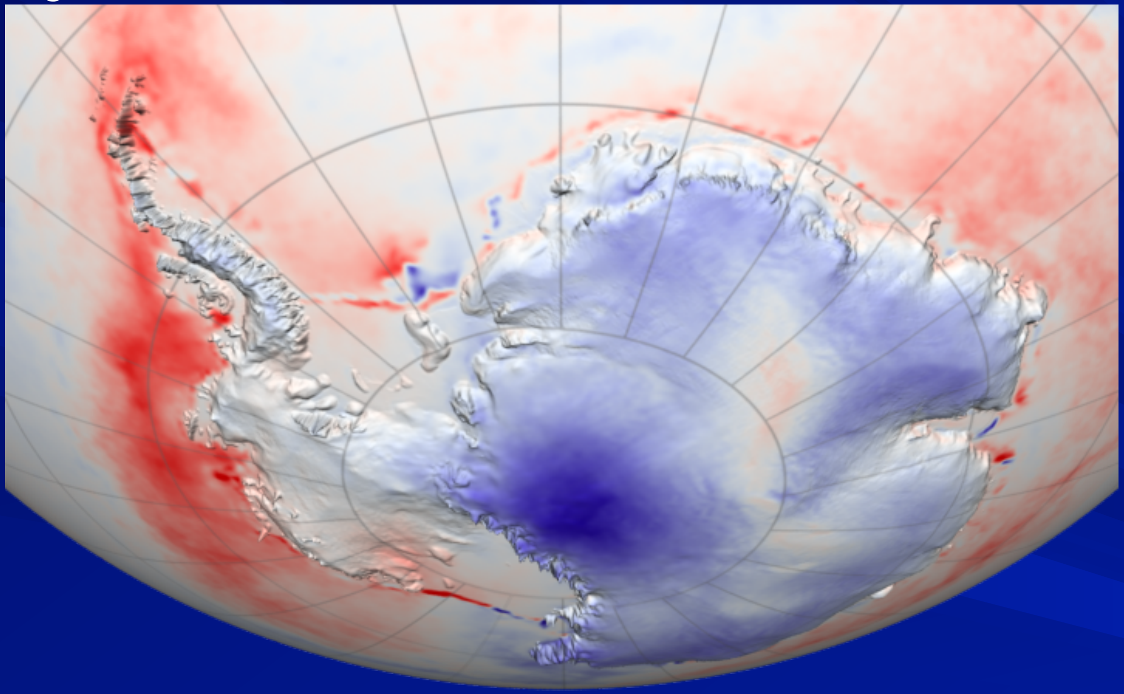
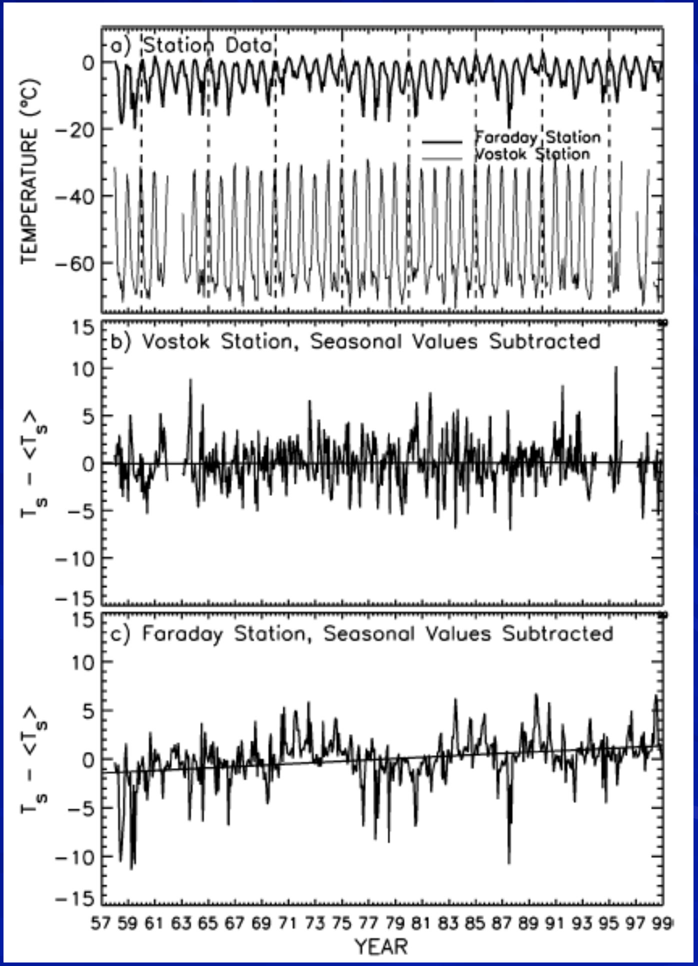
Antarctic Change

1. Peninsula Warming versus Continental Cooling

Figure from NASA-GSFC





Southern Annular Mode trending toward positive index in a warming atmosphere.

(see Thompson and Solomon, 2002, *Nature*; Thompson et al, 2011, *Nature Geosci*)

(Comiso, 2000, *J Clim*)

Antarctic Change

2. Recent Discovery of West Antarctic Warming

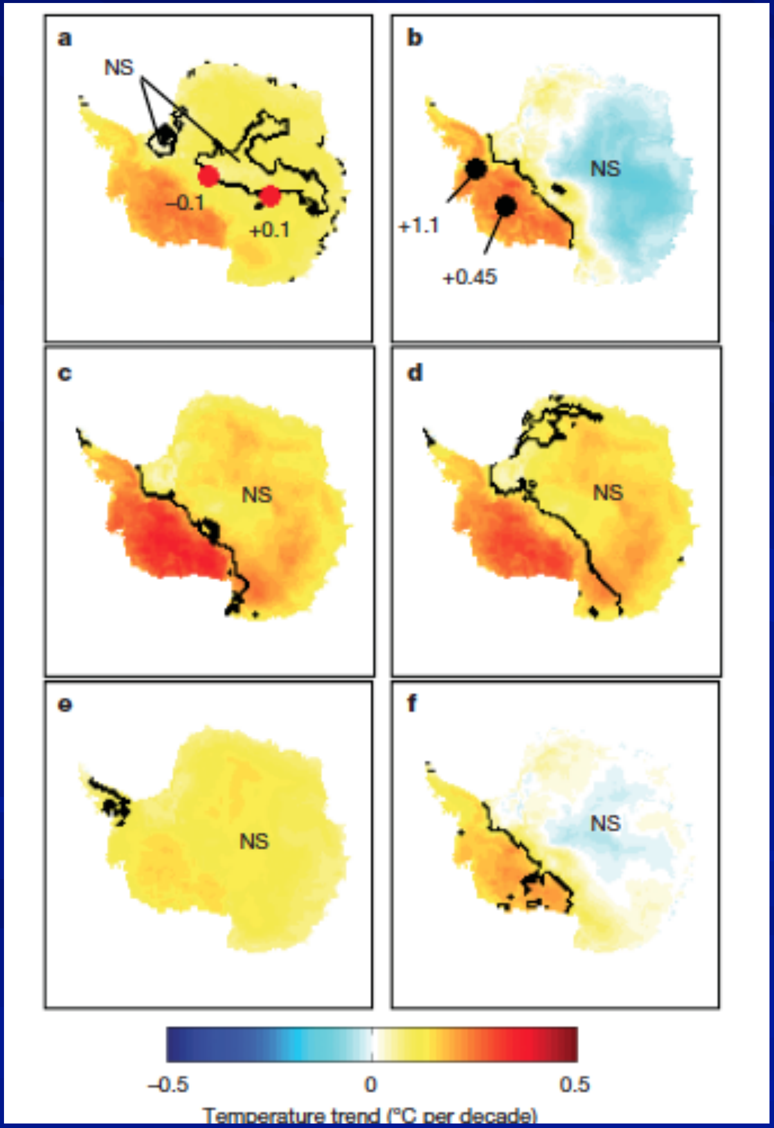


Figure 3 | Spatial pattern of temperature trends (degrees Celsius per decade) from reconstruction using infrared (T_{IR}) satellite data. **a**, Mean annual trends for 1957–2006; **b**, Mean annual trends for 1969–2000, to facilitate comparison with ref. 2. **c–f**, Seasonal trends for 1957–2006: winter (June, July, August; **c**); spring (September, October, November; **d**); summer (December, January, February; **e**); autumn (March, April, May; **f**). Black lines enclose those areas that have statistically significant trends at 95% confidence (two-tailed *t*-test). Where it would otherwise be unclear, NS (not significant) refers to areas of insignificant trends. Red circles and adjacent numbers in **a** show the locations of the South Pole and Vostok weather stations and their respective trends (degrees Celsius per decade) during the same time interval as the reconstruction (1957–2006). Black circles in **b** show the locations of Siple and Byrd Stations, and the adjacent numbers show their respective trends[13] for 1979–1997.

Combining AVHRR Infrared data with surface data from 42 automatic weather stations.

(Steig et al., 2009, *Nature*)

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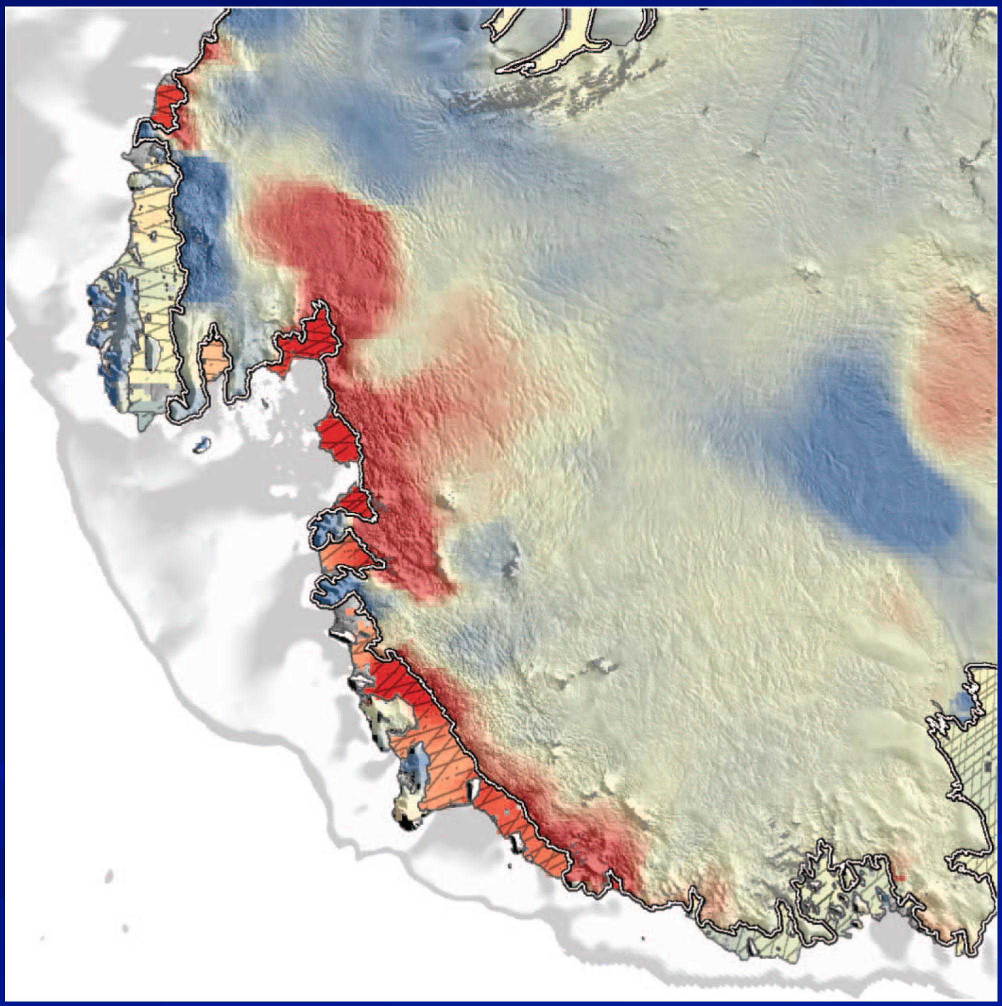
3. West Antarctic Ice Sheet Loss



- Change in surface height on ice shelves and grounded ice.
- Red indicates trend of -0.3 m/year.
- Localized very strong thermal forcing of -40 m/year near deep grounding line of Pine Island Glacier.
- Major cause may be basal melting induced by warming ocean.
- Pritchard et al., 2012, *Nature*.

Surface Melting in West Antarctica

From QuickScat (Nghiem et al., 2007, *Dynamic Planet*)

Widespread melting events in summer 2005

Drainage from surface meltwater can lubricate base of ice sheet and accelerate loss.

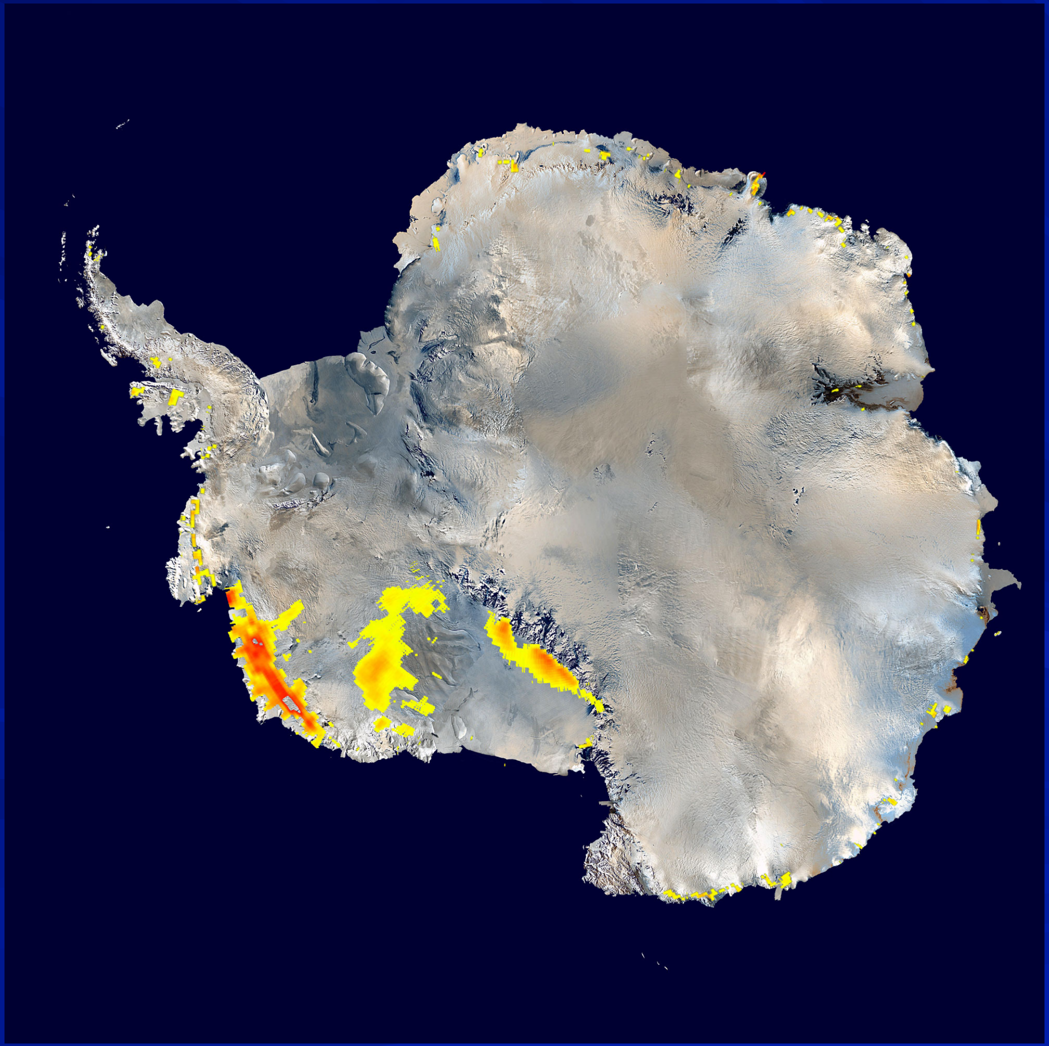
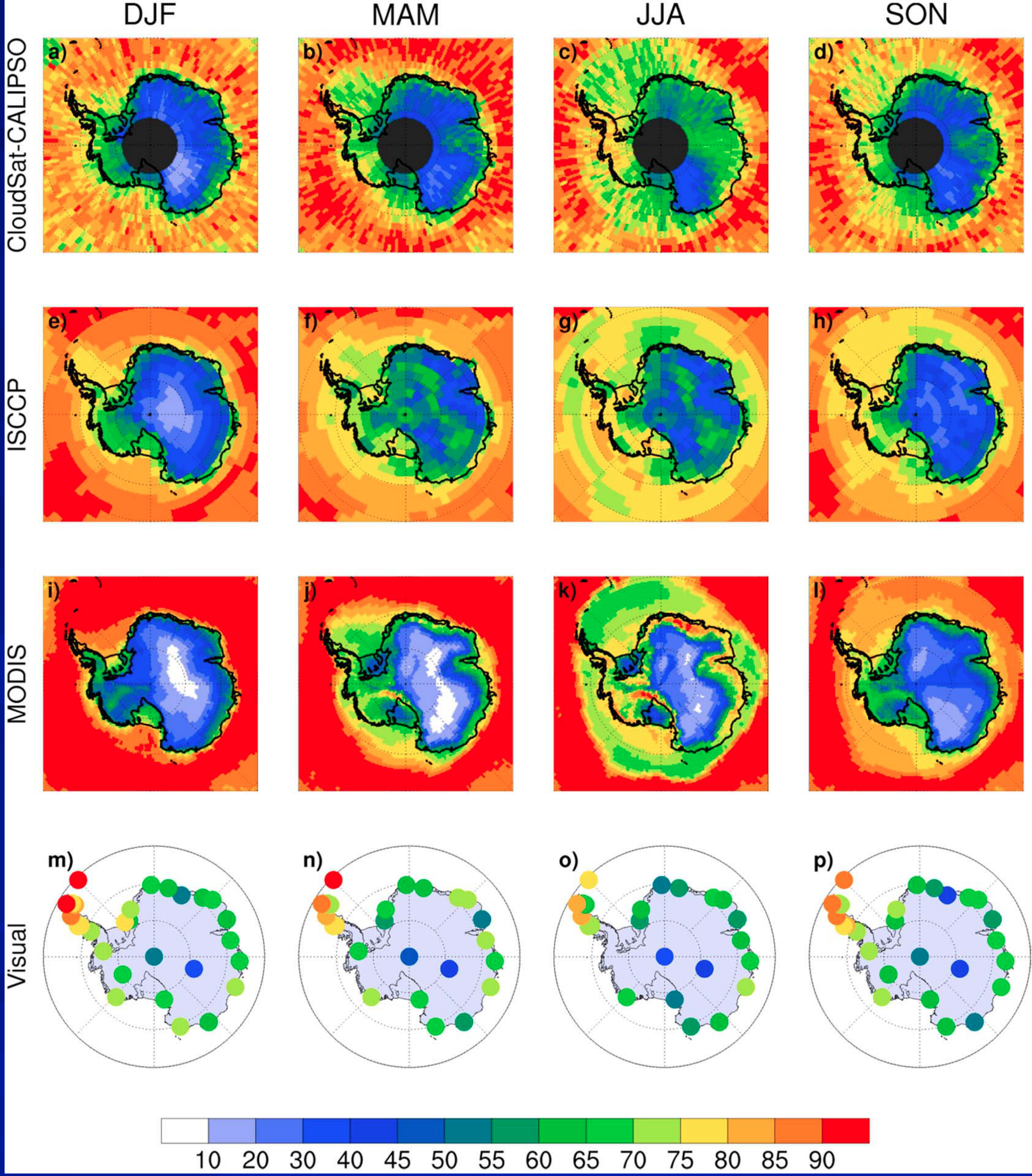


Figure from NASA-GSFC

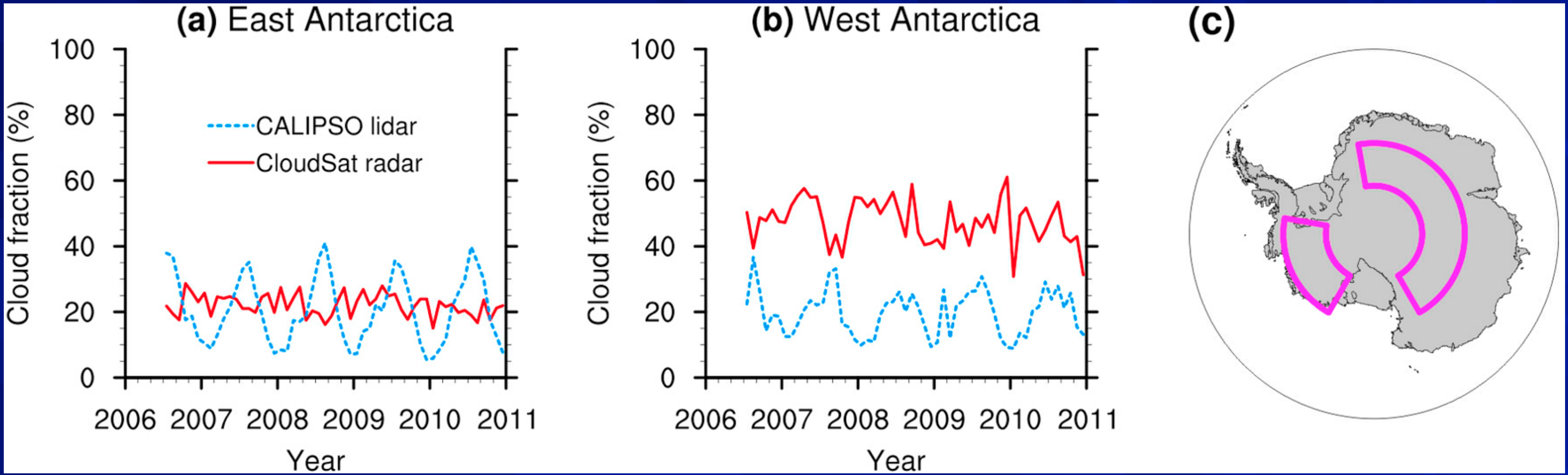
Cloud Amount over Antarctica from Four Sources

West Antarctica subject to intrusions of maritime air leading to increased cloud amount compared with East Antarctica

(Bromwich et al., 2012, *Rev Geophys*; Nicolas and Browmwich, 2011, *J Clim*)



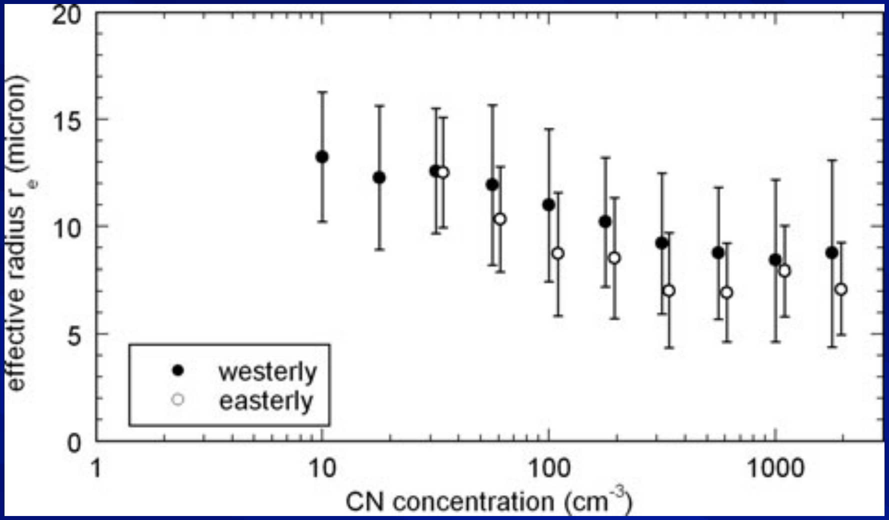
Hints at Antarctic Cloud Particle Size from Active Sensor Data



- CALIPSO lidar sees small particles; CloudSat radar only the larger particles.
  - Threshold is 28-30 microns (see Grenier et al., 2009, *JGRd*).
  - Seasonal cycle shows influence of polar stratospheric clouds in winter.

(Figure from Bromwich et al., 2012, *Rev Geophys*)

Importance of Knowing Cloud Microphysics: An Example from the Arctic

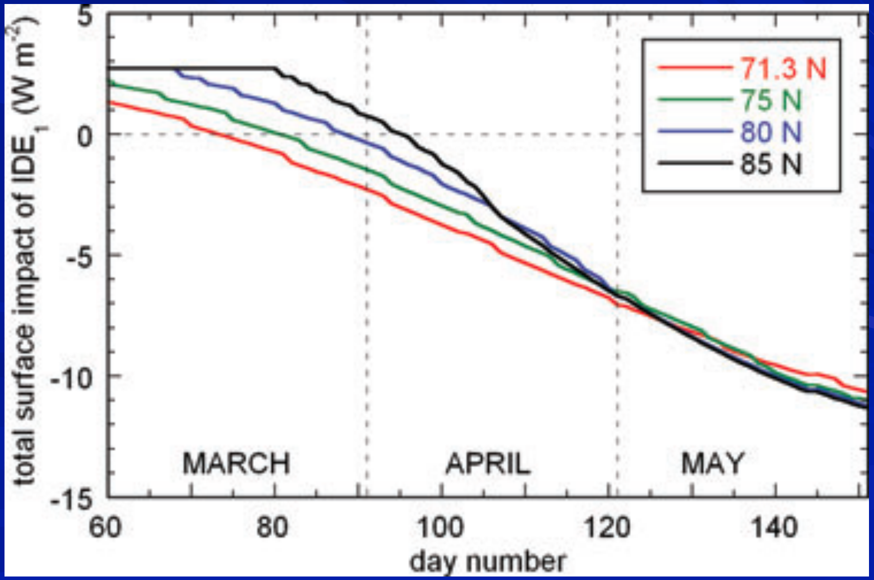


1. Aerosol Indirect Effect in Arctic stratus clouds derived from ground-based FTIR measurements similar to AIRS instrument.

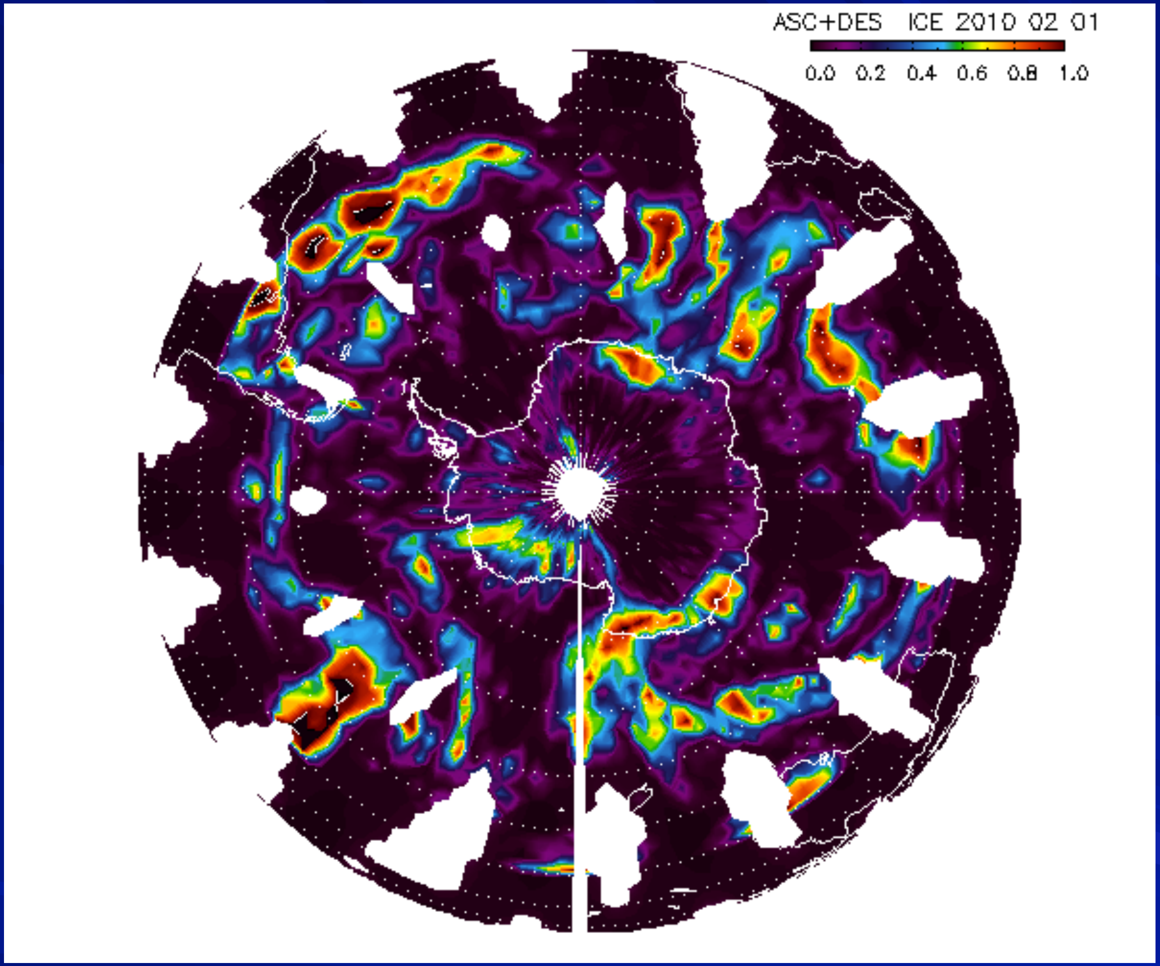
Clouds are optically thin (LWP < 50 g m^{-2}) (Lubin and Vogelmann, 2010, *Tellus B*)

2. Net Indirect Effect as a function of latitude, evolving from spring to summer.

Microphysics play large role in determining a warming versus cooling role for cloud in surface energy budget.



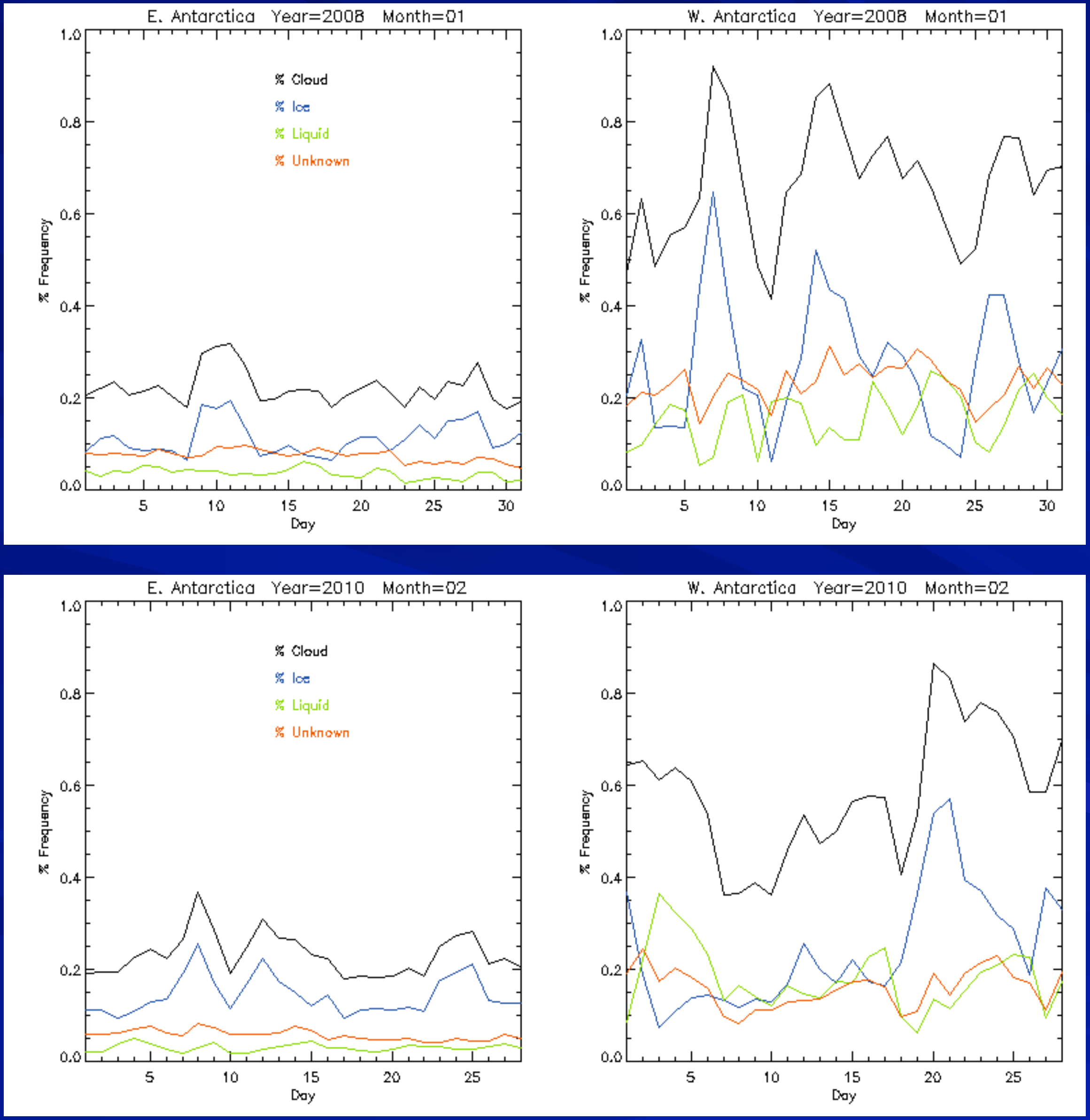
AIRS Retrievals for West versus East Antarctica



Cloud Thermodynamic Phase from AIRS

JAN 2008

FEB 2010



Cloud Optical Depth from AIRS

JAN 2008

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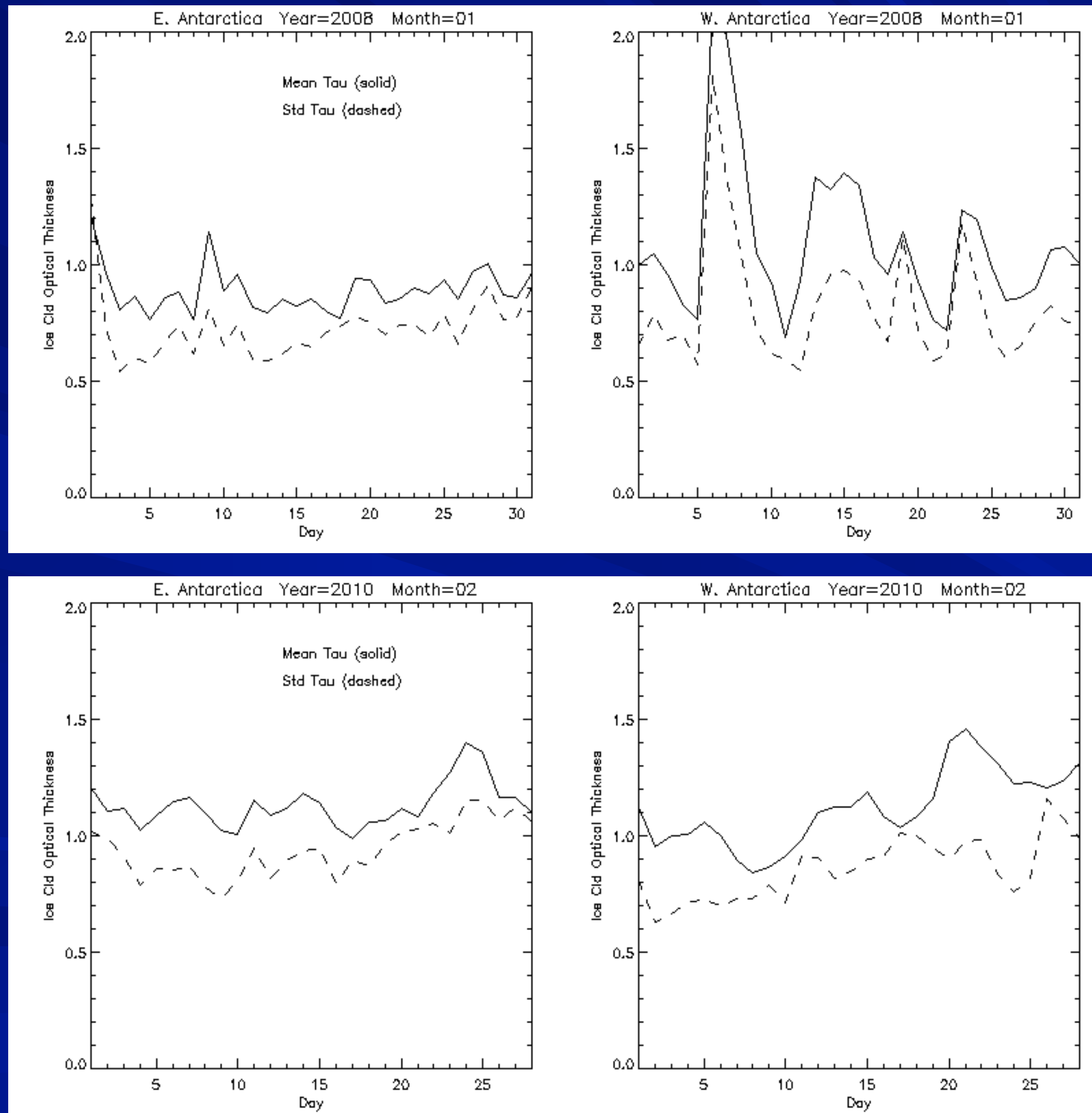
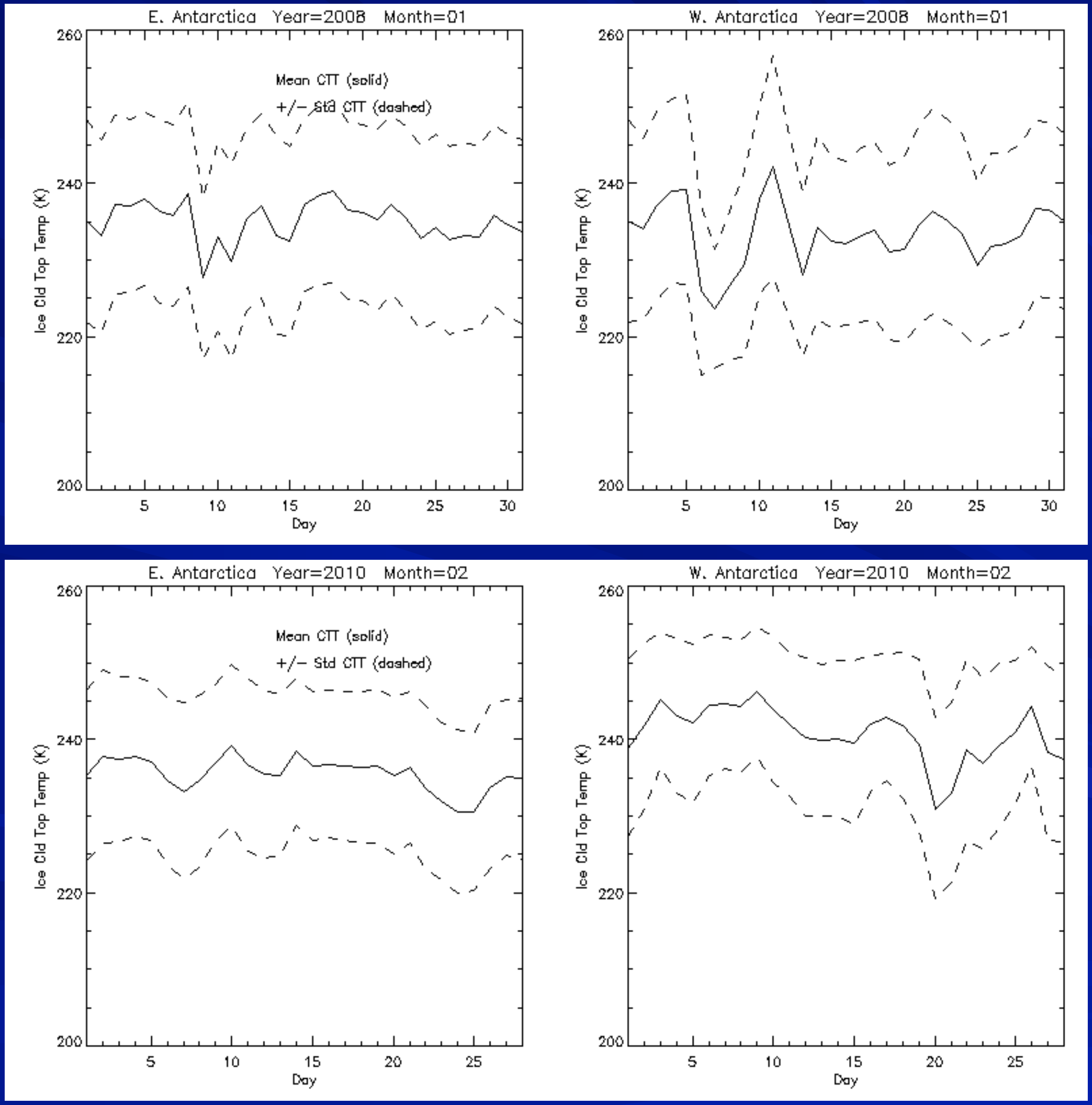


Cloud Top Temperature from AIRS

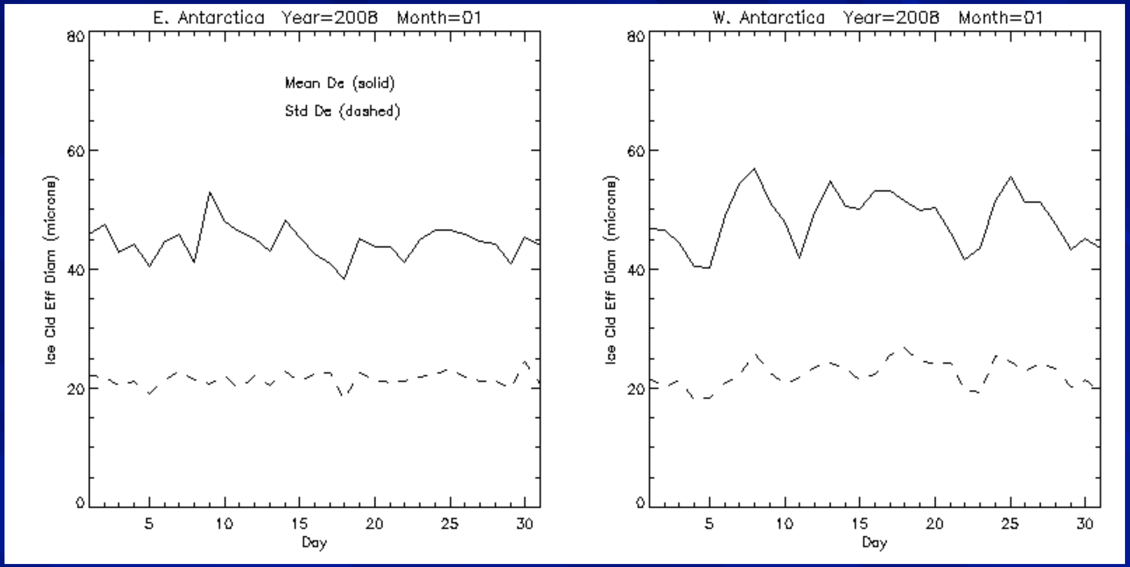
JAN 2008

FEB 2010

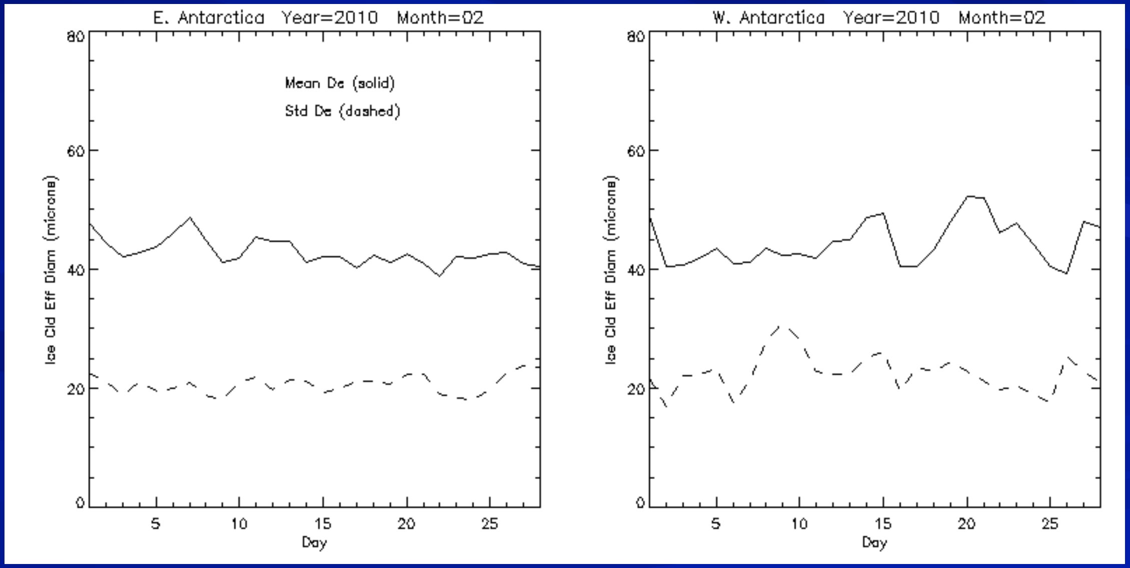


Cloud Effective Particle Size from AIRS

JAN 2008



FEB 2010



Conclusion

- Significantly larger cloud amount over West Antarctica from AIRS, consistent with other sources of information.
- Significant fraction of liquid water cloud over West Antarctica, small fraction over East Antarctica.
- Similar cloud optical depths, but with short term maxima for West Antarctica resulting from maritime air intrusions.
- Somewhat warmer cloud top temperatures over West Antarctica, possibly consistent with lower, liquid water cloud.
- Similar effective particle sizes for West and East Antarctica.
- AIRS will play a unique role in year-round retrieval of cloud microphysical properties, providing retrievals not possible with active sensors.
- B. Kahn, D. Lubin, V. P. Walden, P. Rowe, 2013, *GRL*, in prep.